

Adolescent Brain Development and Drug Abuse  
*Research indicates that brain development is still in progress during adolescence; immature brain regions may place teenagers at elevated risk to effects of drugs*

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A Special Report Commissioned by the Treatment Research Institute  
Philadelphia, PA  
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New scientific discoveries have put a much different perspective on our understanding of adolescent behavior. Research now suggests that the human brain is still maturing during the adolescent years, with significant changes continuing into the early 20s. The developing brain of the teenage years may help explain why adolescents sometimes make decisions that seem to be quite risky and may lead to safety or health concerns. And it may add insights into unique vulnerabilities and opportunities associated with youth.

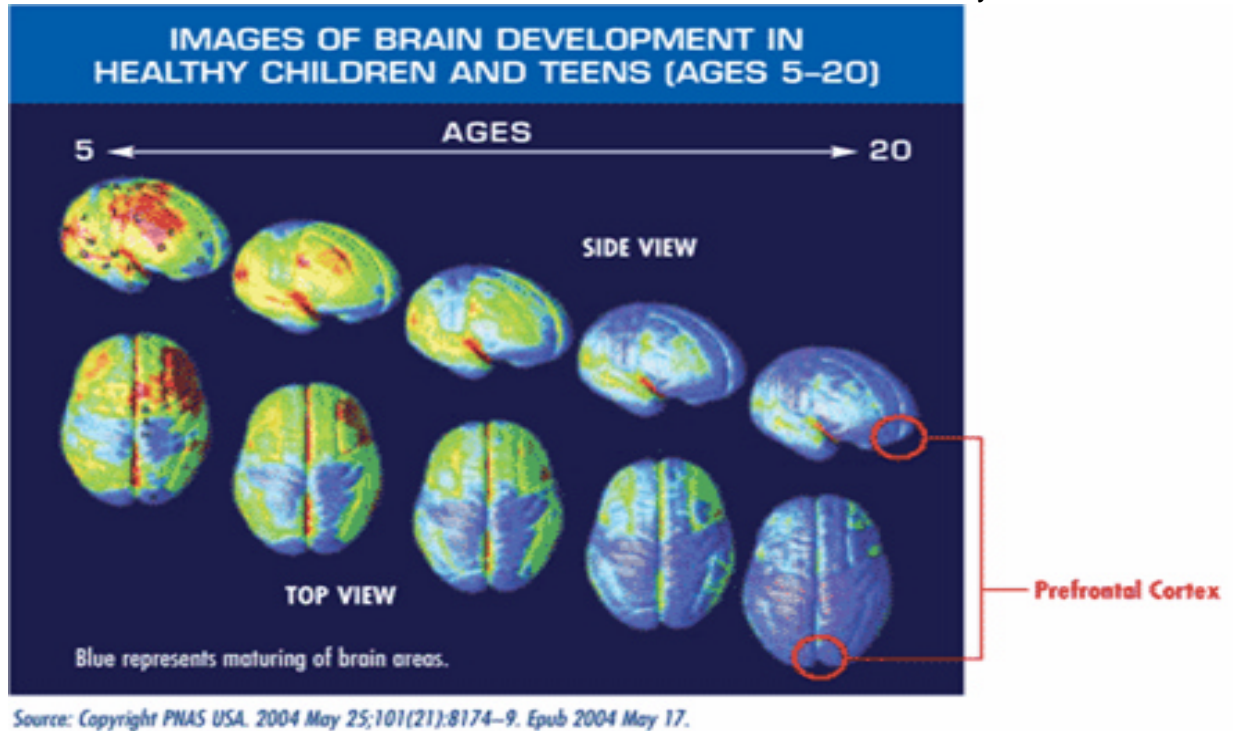
## **WORK IN PROGRESS**

Advanced technologies in brain imaging have provided windows to the developing brain. Based on the pioneering work of Jay Giedd and colleagues at the National Institute of Mental Health (Giedd, 2004), evidence is accumulating that the brain is not fully formed at the end of childhood as earlier thought. The juvenile brain is still maturing in the teenage years and reasoning and judgment are developing well into the early to mid 20s.

During childhood, the brain grows an excessive number of connections between brain cells. At about year 11 or 12, a young person begins to lose or “prune back” a substantial fraction of these connections. This loss is healthy in the long run and is a vital part of growing up. The pruning process clears out unneeded wiring to make way for more efficient and faster information-processing as we become adults. And it promotes building the long chains of nerve cells that are required for the more demanding problem-solving of adulthood.

And the pruning process appears to follow the principle of “use-it-or-lose-it,” according to experts. Thus, neural connections or circuitry that gets exercised as we grow up are retained, while the connections that are not activated or used, get pruned away. Dr. Giedd refers to this process in this way: “Ineffective or weak connections are pruned in much the same way a gardener would prune a tree or bush, giving the plant the desired shape.”

This brain maturation tends to occur from the back of the brain to the front. So the front region of the brain, known as the prefrontal cortex, which is responsible for high-level reasoning and decision-making, does not become fully mature until around the early to mid 20s.



The prefrontal cortex is the part of the brain that enables a person to think clearly, to make good decisions and to control impulses. It is primarily responsible for how much priority to give incoming messages like "Do this now" versus "Wait! What about the consequences?" Because the emotional, "Do this now" regions, predominantly located behind the front of the brain, have progressed with the pruning process, it is difficult for the "Wait" part of the brain to exert much influence. As Psychologist Laurence Steinberg sees it, a teenager's brain "has a well-developed accelerator but only a partly developed brake."

### **IMPLICATIONS FOR UNDERSTANDING BEHAVIOR**

Scientists caution against suggestions of definitive linkages between brain development and adolescent behavior, but there is a growing sentiment among experts that when teenagers are feeling high emotion or intense peer pressure, conditions are ripe for the still-maturing

circuitry in the front part of brain to be overwhelmed, resulting in inexplicable behavior and poor judgments.



This does not mean adolescents can not make a rational decision or appreciate the difference between right and wrong. The teenage brain is quite capable of demonstrating plenty of mental ability. But the teenager, with less than optimal brain-based control mechanisms, is more likely to act impulsively and with gut instinct when confronted with stressful or emotional decisions, without fully appreciating the immediate consequences of their actions.

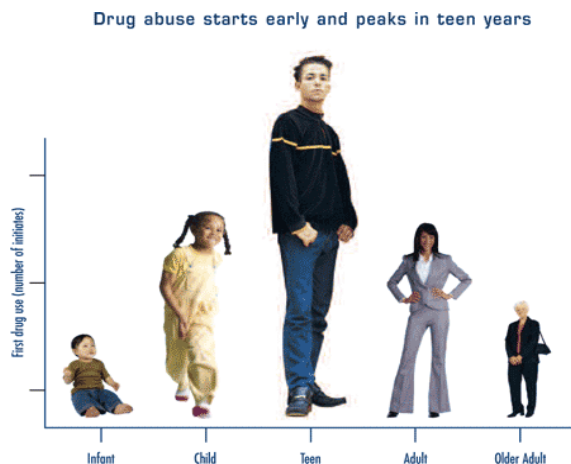
Experts say that even at ages 16 and 17, when compared to adults, adolescents on average are more:

- impulsive.
- aggressive.
- emotionally volatile.
- likely to take risks.
- reactive to stress.
- vulnerable to peer pressure.

- prone to focus on and overestimate short-term payoffs and underplay longer-term consequences of what they do.
- likely to overlook alternative courses of action.

## **THE DEVELOPING BRAIN AND DRUG USE**

Scientists are beginning to explore whether these new discoveries explain adolescent drug use and related impulsive behaviors. Adolescence is a time of experimentation and novelty seeking. One way this occurs with young people is their curiosity about drugs. We know from national surveys that use of alcohol, tobacco and other drugs is relatively common among youth (Johnston et al., 2006). Over half of young people will try an illicit drug at least once during their teenage years, and nearly all of them will have tried either alcohol, tobacco or both at least once before they reach legal age.

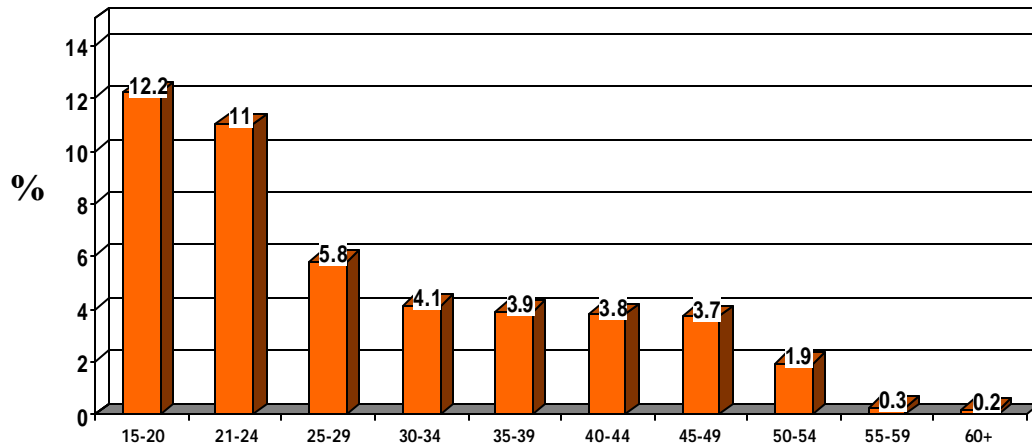


And we also know from national surveys that for alcohol - the drug used most by Americans – young people show higher rates or percentages of alcohol problems compared to older age groups. See the graph below that shows this pattern. For youth aged 15-20 years old, 12.2% met the definition of an alcohol dependence disorder within the past 12 months.

This rate was much higher than the other age groups. For individuals in the 30-34 age group, the rate of alcohol dependence was 4.1%.

### Prevalence of Past-Year DSM-IV Alcohol Dependence: United States, 2001-2002

(Grant, B.F., et al., *Drug and Alcohol Dependence*, 74, 223-234, 2004)



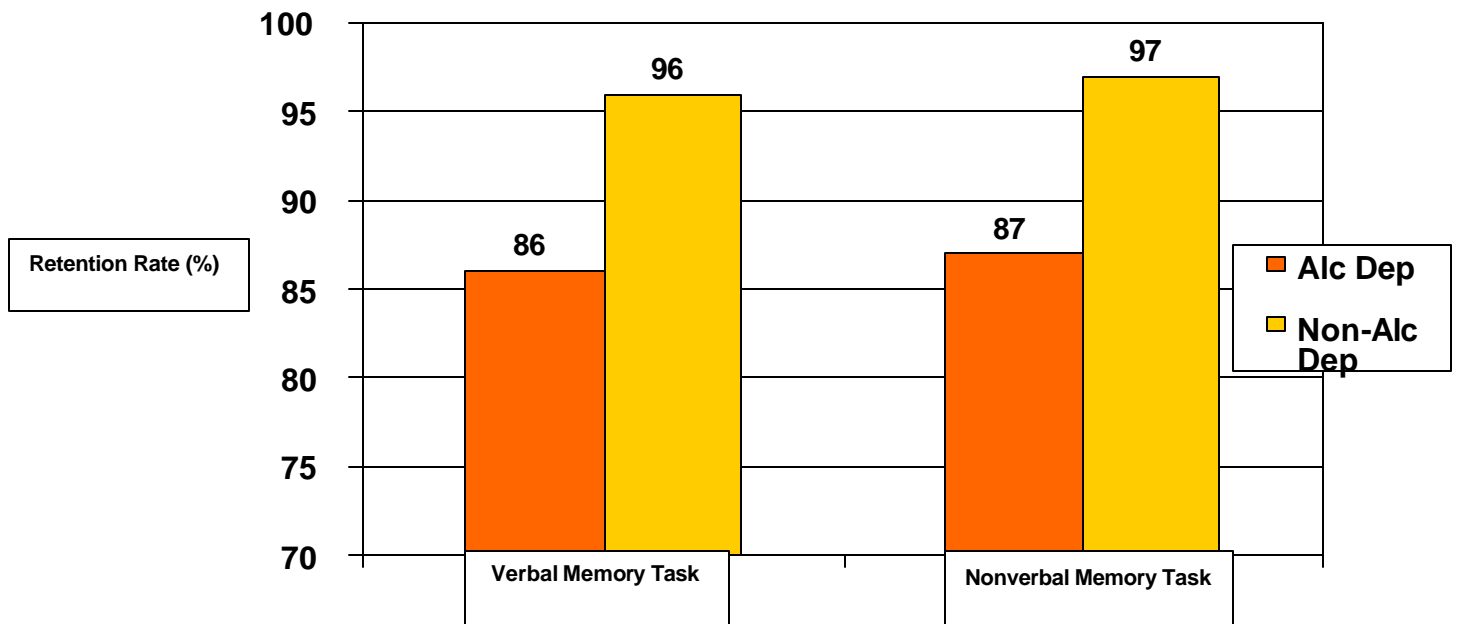
From a neuro-development standpoint, two central questions merit scientific attention: Do neuro-developmental factors predispose adolescents to seek out and abuse alcohol and drugs? And, are there any deleterious effects on brain development as result of drug use in adolescence? Evidence from animal and human data pertains to both questions.

*Are adolescents more vulnerable than adults to abuse drugs?* Several neuro-developmental findings provide provisional answers to this question. As already noted, a developing prefrontal cortex increases the propensity of teenagers to act impulsively and to ignore the negative consequences of such behavior. And there is growing evidence that one direct result of a developing teenage brain is that adolescents subjectively report greater feelings of social disinhibition when drinking alcohol compared to adults (Spear, 2002). This

effect would create a more pleasurable social experience (e.g., contribute to feeling less shy) while drinking compared to adults. All these effects of the developing brain – poor impulse control, favoring low-effort yet thrilling experiences, and heightened sensitivity to the social benefits of intoxication – may contribute to an initial decision to use drugs and make the experience rewarding enough to repeat it.

There are other considerations. In studies of adolescent rats, they are observed to be *less* sensitive to the effects of intoxication than adult rats. They typically consume two to three times as much alcohol for their body weight as adults (Spear, 2002). Adolescent humans also show this diminished sensitivity to intoxication; their higher metabolic rates allow them to consume higher amounts of alcohol (Spear, 2002). A lower sensitivity to alcohol's effects would be consistent with the observation that young people are capable of drinking large amounts of alcohol without feeling all that intoxicated. Hormones have a role here as well. Hormones encourage novelty seeking and promote social competitiveness. The revved-up hormonal production of adolescence may promote drug use to the extent that it represents a novel experience to the youth who is also seeking social approval from peers during the experience.

*Arrested development?* A limited amount of science suggests that the developing brain is prone to the deleterious effects of alcohol. Adolescent rats exposed to various amounts of alcohol have significantly more brain damage in their frontal cortex than their adult counterparts (Spear, 2002). They also show greater damage to their working memory. With long-term use, adolescent rats have shown massive neuronal loss in their cerebellum, basal forebrain, and neocortex (Spear, 2002). In human studies, adolescents with alcohol use disorders ("Alc Dep" in the following table) had nearly 10% smaller volume in the hippocampus (the primary structure for memory) which led to greater memory retrieval deficits than comparisons ("Non-Alc Dep") (Brown et al., 2000).



## **OPPORTUNITIES FOR DRUG PREVENTION & TREATMENT**

Where does this new science lead us? Can an understanding of neuro-development help us do a better job preventing and treating drug use and addiction among teenagers? While it's too early to say if this new knowledge will dramatically impact prevention, there are several things to consider.

- Because many teens begin using substances at a young age and because of their possible deleterious effects on the developing brain, the urgency for prevention is real. Delaying the onset of drug use, especially if it is delayed until adulthood, is better for both brain development and for preventing escalation of use. Teenagers who abuse drugs may avoid permanent neurological damage if they can cut down or abstain.
- The possible dangers of drug use to the developing brain should be emphasized to both youth and parents. These emerging findings should reinforce that youth drug use is associated with more dangers than the vague social and legal consequences often



highlighted in prevention messages. The emerging science suggests deeper consequences - possible brain damage - as well as a greater vulnerability than faced by adults.

- Creating age-appropriate curriculum to educate youth about their developing brain is a need. The emerging sciences of the neurobiology of addiction and of brain development are providing new insights about how drugs affect the brain and how teenagers make critical and life influencing decisions, including their decisions about drug use. Resources are needed to educate youth about this critical new knowledge in brain development. This emerging information can be harnessed to reframe and strengthen current drug prevention approaches by encouraging youth to capitalize on the assets of the developing brain, avail themselves of alternatives to potentially health-compromising risk-taking and to promote personal growth and healthy lifestyles.
- This new science also places importance on educating youth about the skill of using the “thinking breaks” when in an emotional or arousing situation. Conditions under which the developing judgment region of the brain is likely to be challenged, and how to engage in “second thought” mechanisms, should be part of health education classes in schools.
- There is also the vital need to educate parents about these important findings – both because they better explain adolescent behavior and because they present cautionary signs that parents may want to heed. If the seemingly irresponsible behaviors of teens are not truly willful acts but are the result of the brain still “under construction,” parents will want to be more tolerant of such annoying behaviors common during adolescence. The findings also arm parents with a more educated justification for being actively

January 2008

involved in their child's life. Rather than the message: "I need to know where you are and who you are with because you are too immature to be trusted," the more scientifically justified message is: "I need to help you anticipate a risky situation until your brain is fully developed and capable of recognizing the danger signs on your own."

**SUMMARY**

Adolescence is a time when a young person forges a sense of self, experiments with independence and seeks new experiences. This developmental period is also likely to be the years when we observe behaviors that reflect how social pressures and thrill-seeking can override common sense. The juvenile brain responds more quickly and more intensively to excitement, arousal and rewards. Channeling this exuberance toward healthy and growth-enriching experiences is among the important tasks for parents as they raise their teenager and a vital priority for our communities.

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**Suggested Readings**

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